TAXONOMIC SURVEY OF OCCURRENCE, DIVERSITY AND ETHNOBOTANY OF PTERIDOPHYTES IN SOME PARTS OF NASARAWA STATE, NIGERIA

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ABSTRACT

The study was carried out to investigate the taxonomic occurrence of Pteridophytes in Lafia and Doma Metropolis of Nasarawa State, Nigeria. A total of 16 locations were sampled in Lafia and Doma respectively. These locations include wetlands, swamps, forest shade and trees. From these locations, ferns were collected, pressed and identified. Their relative abundances in each location were calculated and their ethnobotanical uses by the local dwellers were documented using structured questionnaires. Ferns were observed only in 12 locations in Lafia and nine locations in Doma. Seven species of ferns were identified namely, *Pneumatopteris afra, Nephrolepis biserrata, N. undulata, N. cordifolia, Adiantum capillus-veneris, Adiantum* sp. and *Pityrogramma calomelanos*. *Pneumatopteris afra* was found to be the most widely distributed fern. Of the ferns observed, terrestrial ferns had the highest occurrence (85.7%) in Lafia with only 50% in Doma. *Pneumatopteris afra* was found to have the highest relative frequency while *Nephrolepis biserrata* and *N. undulata* had the lowest relative frequency in Lafia and Doma. All these species have been reported by the local dwellers to have ethnobotanical uses such as in the treatment of ulcer, fever, typhoid, chest pain, stomach pain and diabetes. Also, *Pityrogramma calomelanos* had the highest percentage awareness by the local dwellers. It is concluded that Lafia is more rich and diverse in fern species than Doma. Locations where ferns were absent are due to the long-term alterations in the microclimatic conditions by various human activities in those places.

INTRODUCTION

In most parts of Africa ferns are more diverse in the eastern than in the western mountains (Moran & Smith, 2001). Ecological and physiological factors such as habitat, seasonality, elevation, soils, rainfall, cloud cover and temperature have been identified as the determinants for the diversity, richness and distribution of ferns in most parts of the world (Kornas, 1993).

Nigerian's first biodiversity report stated that ferns and fern allies have been observed to grow in most ecological zones but different habitats (Akinsoji *et al.,* 2016). Although, ferns have wide coverage in Nigeria, due to habitat change by factors such as unplanned urbanization, over-exploitation of minerals and farming, many species have been reduced, endangered or are on the verge of extinction (Dixit, 2000).

Pteridophytes are often restricted to specific micro-habitats. However, as a result of serious threats faced by these plants coupled with the fact that they are underutilized

and overlooked in this part of the world because of their relatively small size and crytogamic nature, there is need for adequate survey and documentation of their occurrences, locations and economic values. Therefore, this research aimed to investigate the occurrence, diversity and ethnobotany of ferns in Lafia and Doma metropolis, Nasarawa State, Nigeria.

MATERIALS AND METHODS

This study was carried out at Lafia and Doma Local Government areas of Nasarawa State, Nigeria. Habitats assessed for the various diversities of pteridophytes include river banks, streams, forest (under shade), arboreal (top of trees), swamps and some other wet lands. The study was conducted towards the end of rainy season in 2016 and early dry season of 2017. Plants specimens were collected using Random sampling method. Various fern species parts were collected which included leaflet, fronds and roots. The samples collected were all recorded in the field. Representative of all collected fern species or specimens, were also photographed. These specimens were later used for identification and to provide permanent records for future use. The geographical coordinates of each sampling location were taken by using a GPS device.

Mature fern species were collected in each location and pressed, dried, poisoned then mounted on standard herbarium sheets and classified according to standard procedures. Identifications were made with the aid of taxonomic literature (Oloyede & Odu, 2011). In the field proper care was taken in selecting the plant materials to enable correct identification. Specimens were collected in a good condition, free of insect damage or diseases. Voucher specimens are preserved in the Department of Botany Herbarium, Federal University, Lafia.

Ethnobotanical Uses

A total of ninety (90) structured questionnaires were administered to local dwellers of all the locations visited to gather information on the knowledge of the plants by the people, the uses of the plants and the part of the plant that had been used. The relative frequency of occurrence of each fern species was determined to assess the distribution of the species.

$$R\,F = \frac{No\ of\ occurences\ of\ individual\ fern\ species}{No\ of\ occurences\ of\ all\ ferns}\ x\ 100$$

Sørensen Similarity Coefficient was calculated to indicate their floristic similarities between the two towns (Lafia and Doma) as follows:

$$Sc = \frac{2W}{a+b}\ x\ 100$$

where Sc is the similarity coefficient, W is the species occurring in both communities under consideration, a is the number of species occurred in Lafia and b is the number of species occurred in Doma.

The relative abundance of the ferns at each site was determined according to Bongers *et al.* (1988) and Kayode (1999): less than five individuals as Rare; 5 to 10 as Occasional; 11 to 30 as Frequent; 31 to 100 as Abundant and over 100 individuals as Very Abundant.

RESULTS

Ferns occurrence and distribution in Lafia

A total of 16 locations were sampled in Lafia, of which ferns were observed in only 12

Table 1: Sampling Locations In Lafia L.G.A

S/N	DESCRIPTION OF LOCATION	LOCATION CODE	LATI-TUDE	LONDI-TUDE	PRESENCE / ABSENCE OF FERNS
1	Akurba osanya	AKB	8.47104N	8.58747E	Present
2	Opposite triple Z farm	OTF	8.45695N	8.57489E	Present
3	Gandu	GAN	8.45116N	8.57304E	Absent
4	Agudu	AGD	8.51771N	8.52483E	Absent
5	Akunzan tabori	AKTR	8.4105N	8.56368E	Present
6	Beside college of Agric	BCA	8.55723N	8.54292E	Present
7	Opposite college of Agric	OCA	8.51061N	8.52016E	Absent
8	Inside college of Agric	ICA	8.53292N	8.53659E	Present
9	Between lafia and shabu river	B/W L$SR	8.58883N	8.5559E	Present
10	Between lafia shabu river	B/W L$SR2	8.56688N	8.54802E	Present
11	Shabu one	SHBI	8.57557N	8.55119E	Present
12	Shabu two	SHB2	8.56688N	8.54802E	Present
13	Shabu three	SHB3	8.57405N	8.55062	Present
14	Akunzan tabo well	AKTW	8.49018N	8.53358E	Present
15	FUL Auditorium	FUL AUD	8.47066N	8.58688E	Present
16	Tudun amba	TUA	8.49216N	8.50355E	Absent

Table 2: The locations occupied by the ferns and the respective abundance status in Lafia

S/N	Species	Location / Abundance status															
		AKB	OTF	GA	AGD	AKTR	BCA	OCA	ICA	B/WL&SR	B/WL&SR2	SHB1	SHB2	SHB3	AKTW	FULAUD	TUA
1	*Adiantum sp.*	X	X	X	X	X	X	X	X	X	X	X	X	X	√A	X	X
2	*Adiantum capillus-veneris*	X	X	X	X	X	X	X	X	X	X	X	X	X	√A	X	X
3	*Pneumatopteris afra*	√VA	√F	X	X	X	√VA	X	X	√VA	√F	X	√A	√A	X	X	X
4	*Nephrolepis bisserata*	X	X	X	X	X	X	X	X	X	X	X	X	√R	X	X	X
5	*Nephrolepis cordifolia*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	√F	X
6	*Nephrolepis undulata*	X	X	X	X	√F	X	X	√VA	X	√A	√O	X	√O	X	X	X
7	*Pityrogramma calomelanos*	X	X	X	X	√VA	X	X	X	X	X	X	X	X	√A	X	X

KEY: √ means present, X means absent
A – abundant, VA – very abundant, F – frequent, O – occasional, R – rare

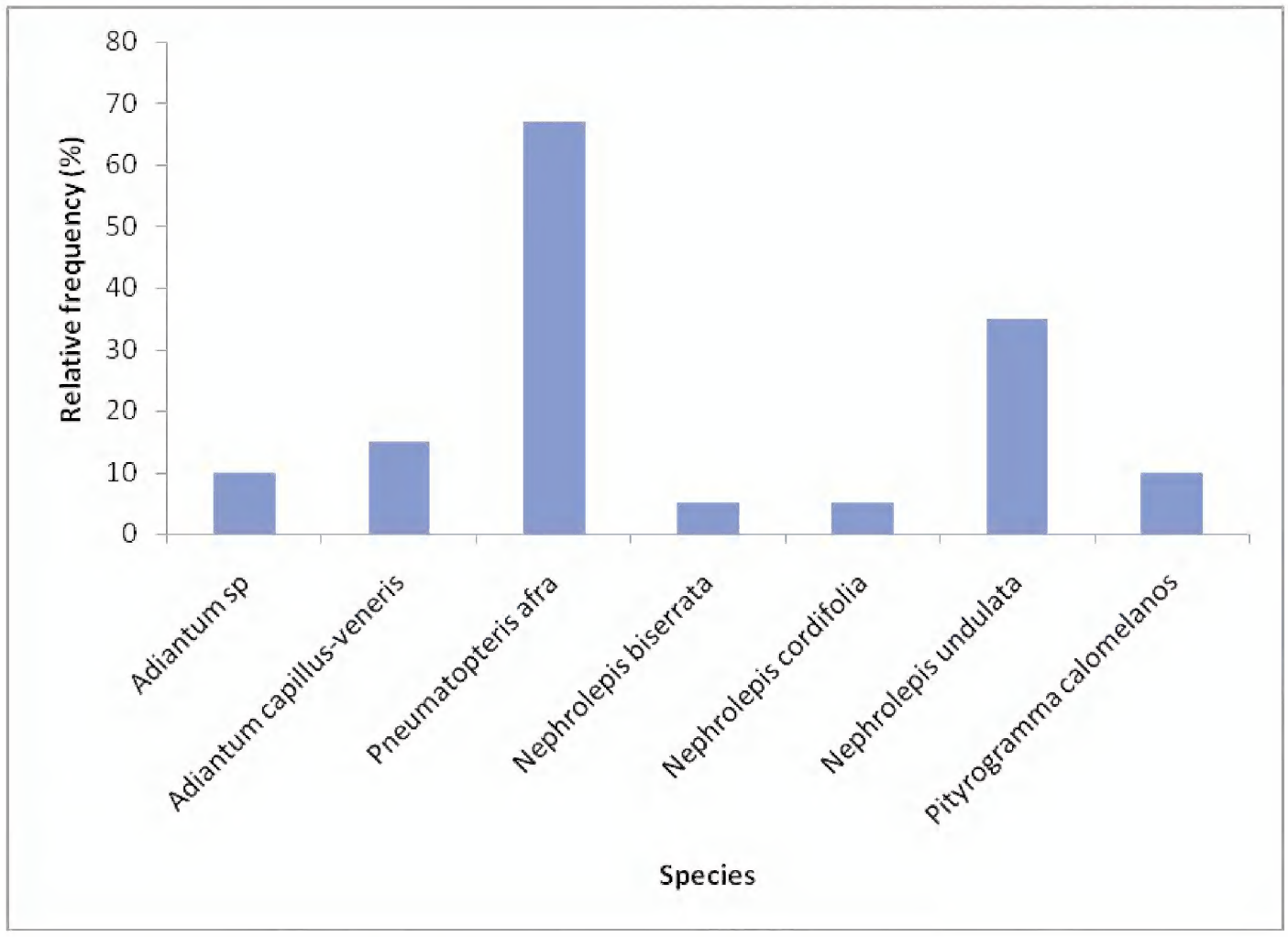

Figure 1: Relative frequency of Fern species in Lafia town

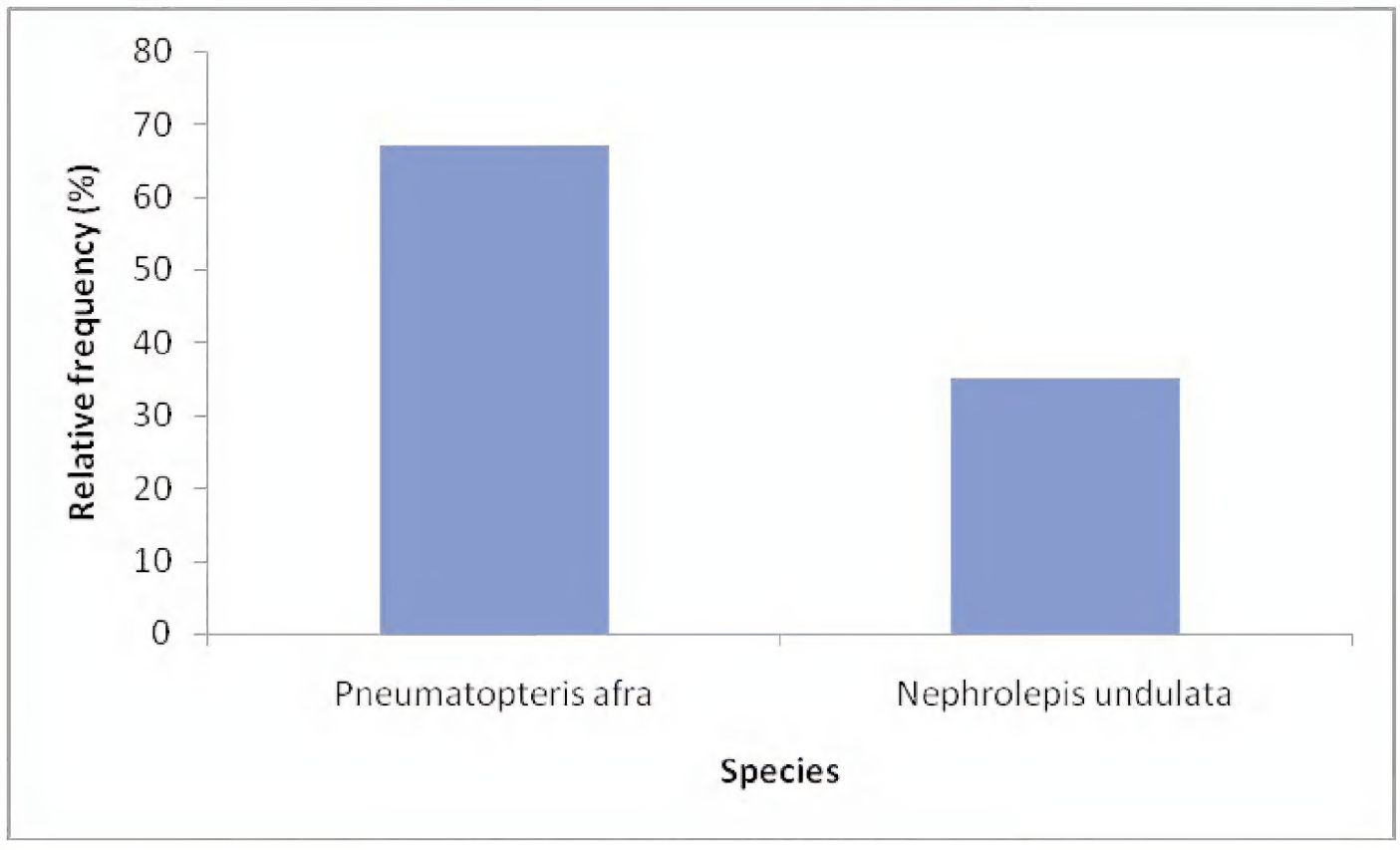

Figure 2: Relative frequency of Fern species in Doma town

Table 3: Sampling Locations in Doma LGA

S/N	DESCRIPTION	LOCATION CODE	LATITUDE	LONGITUDE	PRESENCE / ABSENCE OF FERNS
1	Omenza 1	Omz1	8.39514N	8.35005E	Present
2	Omenz2	Omz2	8.39017N	8.34801E	Present
3	Osota1	OST1	8.39013N	8.3481E	Absent
4	Osota 2	OST2	8.39278N	8.35039E	Absent
5	GSS Doma	GSSD	8.39188N	8.35039E	Present
6	Govt. college Doma	GCD	8.39024N	8.35762E	Absent
7	Arumangye	ARG	8.39004N	8.35762E	Absent
8	Federal Science and Technical College	FSTC	8.39131N	8.34863E	Absent
9	Ogbobula1	OGB1	8.39695N	8.34863E	Present
10	Ogbobula2	OGB2	8.39074N	8.34881E	Absent
11	Okpuripu	OKPU	8.39145N	8.3498E	Absent
12	Okussupa	OKSP	8.3906N	8.34861E	Present
13	Ipugigu	IPG	8.39102N	8.3492E	Present
14	GGSSD formal hostel	GGDFH	8.4043N	8.36809E	Present
15	Campo 1	CMP1	8.46461n	8.43512E	Present
16	Campo 2	CMP2	8.44435N	8.41107E	Present

Table 4: The locations occupied by the ferns and the respective abundance status in Doma

S/N	Species	Location / Abundance status															
		OMZ1	OMZ2	OST1	OST2	GSSD	GCD	ARG	FSTC	OGB1	OGB2	OKPU	OKSP	IPG	GGFH	CMP1	CMP2
1	*Pneumatopteris afra*	√ VA	√ A	X	X	√ F	X	X	X	√ A	X	X	X	X	X	√ VA	√ A
2	*Nephrolepis undulata*	X	X	X	X	X	X	X	X	X	X	X	√ VA	√ VA	√ O	X	X

KEY: √ means present, X means absent
A – abundant, VA – very abundant, F – frequent, O – occasional, R - rare

Table 5: Ethhnobotanical uses of the fern species in Lafia

S/N	SPECIES	% AWARENESS	ETHNOBOTANICAL USES	PARTS USED	MODE OF PREPARATION
1	*Pneumatopteris afra*	90	Typhoid, fever, headache, ulcer	Leaflets, fronds	boiling,
			piles, stomach pain	roots & fronds	Drying
			strengthening of bones	whole plants	drying & boiling
			healing of wounds caused by guinea worm	root	Drying
2	*Pityrogramma calomelanos*	100	enhancement of male sexual cells	root	boiling
			treatment of chest pain,	leaflets	air drying
			healing of stomach pain, fever	fronds	boiling
			treating shortage of blood	leaflets	boiling
			reducing prolonged labour	whole plants	boiling
			breast cancer	root	boiling
3	*Nephrolepis undulata*	30	Snake bite, convulsion, high blood pressure, poisoning, goitre, bone fracture, sickle cell anemia	Whole plants	drying, freshly pounded, boiling
			diabetes	roots	boiling
4	*Adiantum capillus-veneris*	40	Convulsion, diabetes, headache, pile, Gonorrhea, scorpion bite, dysentery	whole parts, roots &fronds	air drying, freshly pounded, boiling
			Measles	leaflets only	Boiling
5	*Adiantum sp*	33.3	fibroid, shortage of blood, diabetes, abnormal menstruation, stomach pain	whole parts	Boiling &air drying
			piles, back pain, waist pain & joint cases	leaf	Boiling &air drying
6	*Nephrolepis cordifolia*	20	sickler cases, high blood pressure, bone fracture, goiter, snake/scorpion bite, skin rashes &diabetes	whole parts &roots	Boiling, freshly pounded, air drying
			headache &rheumatism	leaf	air drying
7	*Nephrolepis biserrata*	30	Eyesight issues, bone fracture, goitre, high blood pressure, snake / scorpion bite &diabetes	Whole parts &roots	Boiling, freshly pounded &drying

Table 6: Ethhnobotanical uses of the fern species in Doma

S/N	SPECIES	% AWARENESS	ETHNOBOTANICAL USES	PARTS USED	MODE OF PREPARATION
1	*Pneumatopteris afra*	50	increases male sexual stamina	Leaf, stem &whole parts	Boiling
			rheumatism, stmach pains, tuberculosis, fever	Leaf, stem &whole parts	Boiling
2	*Nephrolepis undulata*	50	Healing of wounds, asthma, pneumonia, cough &ulcer	Leaf, whole parts	Drying, boiling &freshly pounded

locations (Table 1). Seven species of ferns were identified from the sampled locations in Lafia: *Pneumatopteris afra* (Christ) Holttum, *Nephrolepis undulata* (Afzel.) J.Sm., *Nephrolepis cordifolia* (L.) K.Presl, *Nephrolepis biserrata* (Sw.) Schott, *Adiantum sp*, *Adiantum capillus-veneris* L. and *Pityrograma calomelanos* (L.) Link (Table 2). *Pneumatopteris afra* was found to be the most widely distributed fern in Lafia where it was found in seven locations. Of the ferns observed, terrestrial ferns were most frequent with 85.7% occurrence while epiphytes were least frequent at 14.3% . *Pneumatopteris afra* was found to have the highest relative frequency at 65% while *Nephrolepis biserrata* and *N. undulata* had the lowest (5%) (Figure 1). The similarity coefficient between the two towns is 22.2%.

Ferns occurrence and distribution in Doma

In Doma, from a total of 16 locations sampled ferns were observed in only nine locations (Table 3). However, in Doma, only two species of ferns were recorded, one terrestrial and the other epiphytic, namely *Pneumatopteris afra* and *Nephrolepis undulata* (Table 4). *Pneumatopteris afra* was found to be the most widespread fern in Doma where it was found in six locations. The relative frequency of *Pneumatopteris afra* was greater (66.67%) than that of *N. undulata* (33.34%) (Figure 2).

Ethnobotanical Uses of Ferns in Lafia

The results of the survey of ethnobotanical uses and awareness of the ferns in Lafia are presented in Table 5. Every species was discovered to have ethnobotanical uses among the local population. *Pneumatopteris afra* had 90% percentage awareness and it was used for treating ulcer, fever, typhoid and piles. *Pityrogramma calomelanos* had the highest percentage awareness (100%) and was used for enhancement of male sexual performance and treating chest pain. The lowest percentage awareness (20%) was recorded for *Nephrolepis cordifolia* which was used for treating high blood pressure and skin rashes.

Ethnobotanical Uses of Ferns in Doma

In Doma, *Pneumatopteris afra* had 50% percentage awareness and was used for treating rheumatism, stomach pains and tuberculosis (Table 6). *Nephrolepis undulata* also had 50% percentage awareness and was used for treating wounds, asthma and pneumonia.

DISCUSSSION AND CONCLUSION

The occurrence of ferns in the two towns studied had only two species in common. As reported by Jones *et al.,* (2011), some fern species are highly flexible and are found in nearly all habitats and also have various life forms. High species occurrence in areas with suitable environmental conditions showed that such species have adapted to the environment (Richard *et al.*, 2000). Consequently, the relatively high number of ferns species found in Lafia compared with Doma might be the result from more favourable microclimatic conditions than in Doma, where conditions have been affected by human activities such as deforestation and farming. This is supported by Sumesh *et al.* (2014) who stated that human activities usually increase pressures on plants.

The occurrence of some species in Lafia such as *Pneumatopteris afra, Nephrolepis undulata* and *Adiantum capillus-veneris* with high relative frequencies suggests that these species will persist in this area if the environmental conditions remain favourable. But species like *Adiantum* sp., *Nephrolepis cordifolia, Nephrolepis biserrata* and *Pityrogramma calomelanos* with low relative frequencies are more likely to become

threatened in the future. Also in Doma town, only two ferns were recorded, and *Pneumatopteris afra* was more frequent than *Nephrolepis undulata*. The paucity and often total absence of ferns in some locations sampled in Lafia (four sites) and Doma (seven sites) is a clear indication of the accumulated long-term anthropogenic activities in the areas resulting in loss of ferns species at these sites.

It is concluded that, in comparison, Lafia has a more rich and diverse ferns flora than Doma, and that despite the presence of relatively few species, all have been used by the local dwellers for various economic purposes. Therefore, conservative measures should be put in place by the Government to avoid future extinction of these ferns.

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PHYTOSOCIOLOGICAL NOTES ON THE FERN-MEADOW VEGETATION OF MID-WEST SCOTLAND AND THE NETHERLANDS

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ABSTRACT

On the basis of five phytosociological relevés, the fern-meadow vegetation with *Oreopteris limbosperma* and *Dryopteris cambrensis* from the region around Oban, Argyll, West Scotland is described and compared with similar communities in the Netherlands and West Germany. It is concluded that these fern-meadows can be assigned to the *Luzulo luzuloides-Thelypteridetum limbospermae*, which in Central and continental West Europe is restricted to forest edges. In West Scotland this community is also common in open landscapes, due to the hyperatlantic climate. In comparison with the fern communities in the Netherlands and Germany, the Scottish examples are very rich in fern species, illustrating the optimal development of the community in West Argyll. Possible future development of this community in the Netherlands are discussed in the light of the increase in records of *Oreopteris limbosperma* and the ecological requirements of *Dryopteris cambrensis*.

INTRODUCTION

For a continental phytosociologist, one of the striking features of the vegetation of the coastal lowlands of West-Argyll is the omnipresence of ferns in open landscapes (Figure 1). Well-known is the invasive character of *Pteridium aquilinum* (L.) Kuhn in extensively managed grasslands all over the British Isles (Rodwell *et al.*, 1992), but many other fern species are found in the dense tall-forb vegetation on slopes in the hyperatlantic lowland around Oban. After *Pteridium*, probably *Blechnum spicant* (L.) Sm. is the most frequent species, but also *Dryopteris cambrensis* (Fraser-Jenk.) Beitel & W.R.Buck can be found on virtually every slope and this species is much more abundant than *Blechnum*. Other species which can be found often are, in no particular order, *Dryopteris filix-mas* (L.) Schott, *D. borreri* (Newm.) Newm. ex Oberh. & Tavel, *D. dilatata* (Hoffm.) A.Gray, *D.carthusiana* (Vill.) H.P.Fuchs, *Athyrium filix-femina* (L.) Roth, *Phegopteris connectilis* (Michx.) Watt, and *Oreopteris limbosperma* Holub.

In West-Europe, fern-dominated forest edge communities from lowland, hills and lower mountain areas were recently placed in a newly described alliance, the *Holco mollis-Athyrion felicis-feminae* (Royer *et al.*) Haveman & Weeda (class *Melampyro-Holcetea mollis* Passarge ex Weeda & Haveman; Weeda & Haveman, 2017). The first author who drew the attention to these fern-rich forest edge communities was Wittig (2000), who described *Oreopteris*-rich forest-edges from the German lower mountain ranges in the Rothhaargebirge, Taunus, and Schwarzwald as *Luzulo luzuloides-Thelypteridetum limbospermae* Wittig. Apart from *Oreopteris limbosperma* (syn.:

Thelypteris limbosperma (All.) H.P.Fuchs) also *Athyrium filix-femina*, *Phegopteris connectilis*, *Blechnum spicant*, *Gynmocarpium dryopteris* (L.) Newman, *Dryopteris carthusiana*, *D. dilatata*, and *D. filix-mas* are fern species mentioned for this vegetation type. This *Oreopteris*-community is not strictly oreophytic (growing in the mountain belt): Bremer (2016) and Weeda & Haveman (2017) recorded the *Luzulo-Thelypteridetum* also from the Netherlands, i.e. from the lowlands of Northwest-Europe. Rodwell *et al.* (1992) described a similar community as *Thelyptris limbosperma-Blechnum spicant* community (U19) from moist base-poor peaty soils on steep, sheltered banks at low to moderate altitudes through the wetter west and north of Britain. Remarkably enough, other fern species are rare in this community: only *Polypodium vulgare* L. and *Athyrium distentifolium* Tausch ex Opiz are mentioned in the table published by these authors. Weeda & Haveman (2017) included this British community in the *Luzulo-Thelypteridetum*.

During a three-weeks summer holiday in July 2017, I was able to study some of the fern-meadow communities in the wider surroundings of Oban, West-Argyll, Scotland. I was especially interested in the communities with the alleged mountain-dwelling *Oreopteris limbosperma* and *Dryopteris cambrensis*, because the latter is very rare in the Netherlands. From the species composition, it was immediately clear that the Scottish fern-meadow community bears a very close resemblance to the *Luzulo-Thelypteridetum*, but also that it had characteristic features of its own. In this paper, I will describe this community on the basis of a few phytosociological relevés. It will be compared with the continental fern communities of the aforementioned *Holco-Athyrion* and more in particular the *Luzulo-Thelypteridetum*, in order to gain a better understanding of these communities, both in hyperatlantic Scotland and the subatlantic Netherlands.

Figure 1. Fern-meadow on a lowland hillside in West-Argyll near Loch Fyne (photo: R. Haveman)

METHODS

On July 6th and 7th 2017, I made five phytosociological relevés of fern-rich forest-edges in Ardcastle Forest at the shore of Loch Fyne and the area of Glencruitten House just outside Oban, according to the methods of the French-Swiss school (Mueller-Dombois & Ellenberg, 1974; Westhoff & Van Der Maarel, 1978). In floristically homogeneous parts of the vegetation of 8-20 m^2, all species were recorded, and their abundance was estimated using the 9-level extended scale of Braun-Blanquet (Westhoff & Van Der Maarel, 1978) in every single layer (tree, shrub, field, and moss layer). The relevés were digitised and stored in TurboVeg (Hennekens & Schaminée, 2001) in the personal database of the author. After export from TurboVeg, the relevés were imported in JUICE (Tichý 2002) for further analysis. In JUICE, all species were ordered according to their phytosociological position according to Weeda & Haveman (2017). Both a full and a (heavily abbreviated) synoptic table (in frequency percentages) of constant species (frequency > 40%) were exported, and the synoptic table compared with the synoptic tables published by Weeda & Haveman (2017) and Wittig (2000) by arranging them in a longitudinal order (Scotland-the Netherlands-Germany). In the full table, all pteridophytes are included, as well as all species occurring in more than one relevé, or in one relevé with a cover ≥ 5%. In the synoptic tables, only the species with a frequency > 10% are included in at least one column.

RESULTS

In the Scottish relevés (Table 1), 11 fern species were recorded in total, and one fern hybrid. The most frequent fern species in the table is *Blechnum spicant* (in all five relevés), followed by *Oreopteris limbosperma*, and *Dryopteris cambrensis* (both in four relevés). In all relevés, *Dryopteris* species have an abundance prevalence over the other fern species. Other species recorded in at least four out of five relevés are *Luzula sylvatica* (Huds.) Gaudin, *Holcus mollis* L., *Hylocomium splendens* (Hedw.) Schimp., *Rhytidiadelphus squarrosus* (Hedw.) Warnst. and *Polytrichum formosum* Hedw.. In all relevés, more than one fern species was found, and relevé 1 in Table 1 is especially rich in ferns: in the vegetation sample of 20 m^2 9 pteridophytes were recorded.

There are clear differences between the Scottish fern-communities with *Oreopteris limbosperma* and *Dryopteris cambrensis* (Table 2, column 1), and the *Luzulo-Thelypteridetum* in the Netherlands (Table 2, column 2) and Germany (Table 2, column 3). Especially striking is the richness in ferns in the Scottish community: on average, 6.2 fern species are recorded in the Scottish relevés, a number that declines strongly when going to the suboceanic regions in the Netherlands and Germany (*viz.* 3.9 and 3.4 respectively). Also their absolute number in the Scottish dataset is higher than in the other two (12, vs. 7 and 9 respectively), although the number of Scottish relevés is evidently lower than in the other two groups. *Dryopteris cambrensis*, *D. borreri* and *Pteridium aquilinum* are exclusively or, in case of the latter, mainly recorded in the Scottish relevés, although it cannot be ruled out that *Dryopteris affinis* Fraser-Jenk., mentioned in one relevé from Germany, is in fact *D. borreri*. Also *Blechnum spicant* and *Dryopteris filix-mas* have a clear optimum in the Scottish relevés, and the same holds true for *Holcus mollis*, *Luzula sylvatica*, *Epilobium montanum* L., *Betula pendula* Roth (juveniles), and the mosses *Hylocomium splendens* and *Rhytidiadelphus squarrosus*. Typical for the Dutch relevés are *Molinia caerulea* (L.) Moench and *Quercus robur* L. (juveniles), whereas the German relevés are differentiated by *Luzula luzuloides* (Lam.) Dandy & Wilmott. However, the three regional groups of relevés have many taxa in

Table 1. Full table of relevés of fern-rich communities in West-Argyll.
Location: G = Glencruitten House, Oban; A = Ardcastle Forest.

Table number	1	2	3	4	5
Relevé number (RH 17.)	167	164	165	168	166
Date (July 2017)	7	6	6	7	7
Location	G	A	A	G	G
Area (m^2)	20	8	10	20	10
Exposition	NW	N	Z	N	W
Inclination (degrees)	45	40	45	80	80
Total cover (%)	100	99	95	100	100
Cover herb layer (%)	95	90	90	95	80
Cover moss layer(%)	80	100	10	80	70
Avg. height herb layer (cm)	60	80	60	60	60
Max. height herb layer (cm)	120	120	90	120	80
Pteridophytes					
Blechnum spicant	+	2a	+	3	2a
Oreopteris limbosperma	+	3	2b	2a	.
Dryopteris cambrensis	2a	3	3	.	2b
Pteridium aquilinum	2b	2b	2a	.	.
Dryopteris filix-mas	+	2a	2b	.	.
Dryopteris dilatata	3	+	.	.	2a
Dryopteris borreri	+	.	.	2a	.
Athyrium filix-femina	2b	.	.	.	2a
Dryopteris carthusiana	.	.	.	3	4
Phegopteris connectilis	2a	.	.	.	.
Polypodium vulgare	.	+	.	.	.
Dryopteris x deweveri	.	.	.	.	2b
Melampyro-Holcetea					
Holcus mollis	+	+	2a	+	1
Luzula sylvatica	2b	+	2b	4	+
Oxalis acetosella	+	.	.	.	+
Epilobietea					
Epilobium montanum	+	.	+	+	1
Digitalis purpurea	1	.	1	.	+
Scrubs and juvenile trees					
Rubus subgen. *Rubus*	2a	+	.	.	2b
Betula pendula	.	+	.	+	+
Rubus spectabilis	2a	.	.	.	.
Mosses					
Hylocomium splendens	4	3	2a	2b	2a
Rhytidiadelphus squarrosus	2b	1	2m	4	2b
Polytrichum formosum	2m	3	2a	.	1
Lophocolea heterophylla	2m	1	.	.	.
Sphagnum capillifolium	.	3	.	2a	.
Peltigera didactyla	.	.	.	+	1
Lophocolea bidentata	2m	.	.	.	.
Dicranum scoparium	2m	.	.	.	.
Campylopus pyriformis	.	.	2a	.	.
Kindbergia praelonga	.	.	.	.	2b
Other species					
Deschampsia cespitosa	+	.	.	+	.
Ranunculus repens	+	.	.	.	+
Potentilla erecta	.	+	+	.	.
Agrostis capillaris	.	1	.	+	.

Table 2. Synoptic table of Oreopteris limbosperma communities in Scotland (column 1, source: Table 1), the Netherlands (column 2, source: Weeda & Haveman 2017), and Germany (column 3, source: Wittig 2000).

Column	1	2	3
Country	Sc	NL	Ge
Number of relevés	5	11	21
Pteridophytes			
Dryopteris cambrensis	80	.	.
Dryopteris borreri	40	.	.
Polypodium vulgare	20	.	.
Dryopteris x deweveri	20	.	.
Pteridium aquilinum	60	9	.
Blechnum spicant	100	64	24
Oreopteris limbosperma	80	100	100
Dryopteris dilatata	60	55	57
Athyrium filix-femina	40	64	76
Dryopteris carthusiana	40	64	14
Phegopteris connectilis	20	36	33
Dryopteris filix-mas	60	.	14
Gymnocarpium dryopteris	.	.	14
Dryopteris affinis	.	.	5
Hylocomium splendens	100	.	.
Pseudoscleropodium purum	20	55	.
Potentilla erecta	40	45	.
Holcus mollis	100	27	43
Atrichum undulatum	20	45	10
Oxalis acetosella	40	9	43
Digitalis purpurea	60	9	43
Rhytidiadelphus squarrosus	100	18	14
Polytrichum formosum	80	64	43
Rubus species	60	73	52
Agrostis capillaris	40	45	67
Juncus effusus	20	45	33
Luzula sylvatica	100	.	52
Epilobium montanum	80	.	24
Betula pendula	60	.	5
Rubus idaeus	20	.	71
Molinia caerulea	.	73	.
Quercus robur	.	55	.
Deschampsia flexuosa	.	27	51
Dicranella heteromalla	.	45	5
Galium saxatile	.	18	48
Pellia epiphylla	.	55	14
Luzula luzuloides	.	.	81

common, like *Dryopteris dilatata*, *Athyrium filix-femina*, *Phegopteris connectilis*, *Atrichum undulatum* (Hedw.) P.Beauv., *Polytrichum formosum*, *Rubus* L. subgen. *Rubus*, *Agrostis capillaris* L., and *Juncus effusus* L. Several other species are common to two regions, whereas they are lacking from the third. *Potentilla erecta* (L.) Raeusch. is an example, which was found in both the Scottish and the Dutch communities, and not in the German.

DISCUSSION

Phytosociological Assignment

The here described Scottish fern-meadows are at least for the greater part to be assigned to the *Luzulo luzuloides-Thelypteridetum limbospermae*, on the basis of the presence of the characteristic species *Oreopteris limbosperma* as well as the constant species, with many pteridophytes and other species which are found in both the Scottish relevés as well as in the German and/or the Dutch plots. The last relevé, without *Oreopteris*, probably represents a fragmentary example of this association. As was shown though, the Scottish fern-meadows have their own characteristics, with several species not found in the suboceanic forms of the association. Especially typical is *Dryopteris cambrensis*. According to Fraser-Jenkins (2007), this species has its distribution centre in oceanic Europe. In the British Isles it is common in Scotland, contrary to its name less so in Wales, and rather rare elsewhere (Page 1997; Trewren 2014). Considering this, the Scottish fern-meadows could probably be described as a separate subassociation (*Luzulo luzuloides-Thelypteridetum dryopteridetosum cambrensis* prov.) but, at this stage, a formal description of such a subassociation is rejected, since the available dataset is too small for a proper assessment.

Figure 2. Abundant fern growth in a forest edge, Oban, Argyll. Apart from *Pteridium aquilinum*, the vegetation is formed mainly by *Dryopteris* species and *Oreopteris limbosperma* (photo: R. Haveman)

Ecology

In the German lower mountain belt, the *Luzulo-Thelypteridetum* is almost strictly confined to forest edges (Wittig, 2000), and the same applies to the situation in the Netherlands (Weeda & Haveman, 2017). In Scotland, the community has a much broader ecological amplitude. Although it is frequently found in forest edges (relevés 3-5 in Table 1, Figure 2), it also develops frequently at forest clearings on suitable soils (relevés 1 and 2 in Table 1, Figure 3). Typical species of woodland clearings (grouped under the heading of *Epilobietea* and Scrubs and juvenile trees in Table 1) are not confined to the latter environment: they are equally present in the relevés from forest edges, and also in the relevés from Germany (Table 2 column 3, less so in the Dutch relevés). Unfortunately, no relevés were made in the stands on the third environment where the community is found, *viz.* abandoned and extensively managed grasslands (Figure 1). However, several short checks of the stands in this situation made clear that the species composition of the vegetation here is very similar to the community which develops in forest edges or at forest clearings.

The abundant occurrence of the combination of *Oreopteris limbosperma*, *Blechnum spicant*, *Athyrium filix-femina*, and several *Dryopteris* species outside the buffered forest micro-climate indicate the high air-humidity and annual rainfall in this part of the UK, where water availability is never a problem (see also Knaben 1950, who drew the same conclusion after study of the fern-communities of West-Norway). According to the climate maps of the Met Office (www.metoffice.gov.uk), the region directly around Oban has an average annual rainfall of 1,700-2,200 mm, which is 2.5 to 3 times the amount in the Netherlands. The German lower mountains receive more rain than the Netherlands, but not as much as the Oban region: the higher regions of the Rothaargebirge e.g., have an average annual rainfall of 1,000 mm (www.wetter.de). Where the *Luzulo-*

Figure 3. A species rich fern community in a forest clearing in Glencruitten House forest, Oban, Argyll (photo R. Haveman)

Thelypteridetum grows in zonation with *Pteridium*-dominated communities, the first is confined to the steep banks, or the shelter of woodlands (Figure 4). Probably this is caused by difference in water demand, which is higher in *Oreopteris* than in *Pteridium* (Weeda & Haveman, 2017). In this respect, a striking description of the edaphic demands of *Oreopteris limbosperma* is given by Page (1997): "... *niches where trickling acidic peaty water provides the most constant surface run-off or subterranean seepage, creating cool and constantly moist but well-aerated edaphic conditions* ..."

In West-Argyll, the *Luzulo-Thelypteridetum* can form complexes with different types of grasslands. On the least fertile situations, the grasslands can be assigned to the class *Nardetea* Rivas Goday et Borja Carbonell. On soils with a somewhat better availability of nutrients, the main grassland type that is found in complex with the fern-meadow community is the *Lolio-Cynosuretum* Tüxen (alliance *Cynosurion cristati* Tüxen, class *Molinio-Arrhenatheretea* Tüxen). Usually, both *Nardion* and *Cynosurion* grasslands are grazed by cattle or sheep. Where the grassland is mown, especially at the bottom of valleys, the grassland vegetation resembles the *Crepido-Juncetum acutiflori* Oberdorfer, a grassland community characteristic for peaty soils with laterally water movement and seepage. It is remarkable that this last grassland type is also mentioned by Bremer (2016) when he discusses the landscape in which the *Luzulo-Thelypteridetum* is found.

In *The vegetation of Scotland*, the classic book edited by Burnett (1964), *Oreopteris limbosperma* is mentioned only in the context of sub-alpine scrubs and fern-meadows (p. 162-163, and p. 516). Only one remark in the chapter on the history and regional patterns in Scottish vegetation (p. 574) associates the species with burning on north-exposed slopes in the Northern Highlands. The occurrence of fern-dominated forest edges

Figure 4. Abandoned hillside meadow with fern encroachment. Large areas are covered by *Pteridium aquilinum* (in the background and in the lower right corner). Steep banks are invaded by *Oreopteris limbosperma* and *Dryopteris* species (lower left corner, and the linear structure in the centre of the photo). Oban, Argyll (photo: R. Haveman)

and fern-meadows in the lowlands (other than those dominated by *Pteridium aquilinum*) like those in the studied part of Argyll, are completely neglected. The same holds true for the description of the fern-dominated communities in Rodwell's *British Plant Communities* (Rodwell *et al.*, 1992). The already mentioned *Thelypteris limbosperma-Blechnum spicant* community (U19), which is placed in the *Dryoptero-Calamagrostidion* Nordh. alliance (class *Betulo-Adenostyletea* Br.-Bl.) by the authors with some reserve, is also considered to have its main distribution at higher altitudes, although it was recorded as low as 245 m above sea level. According to Page (1997), *Oreopteris limbosperma* might reach its highest abundance in western Scotland anywhere on a world scale, and here it can be found nearly from sea-level to about 880 m.

The Dutch *Oreopteris* Community In Comparison

Bremer (2016) and Weeda & Haveman (2017) characterised the *Luzulo luzuloides-Thelypteridetum limbospermae* in the Netherlands as an association in development (an association in statu nascendi; Westhoff 1990). The current distribution of *Oreopteris limbosperma* in the Netherlands is the result of a rather recent increase (Figure 5). In the period before 1950, the species was only found in 45 standard grid cells (5x5 km). This increased in a short time to 71 in 1955, possibly as a result of a better recognition of the species or intensified surveys. Until 2000, the number of grid cells in which the species was found increased gradually to 103, in order to increase exponentially in the following years, to 176 in 2015 (verspreidingsatlas.nl). This expansion of *Oreopteris* can be attributed to the development of the landscape in the 20th Century. Most of the recent population growth of *Oreopteris* in the Netherlands is observed in forest plantations (mostly of Scots pine, *Pinus sylvestris*) in former heathland areas from the late 19th and early 20th Century (Bremer, 2016; Weeda & Haveman, 2017). Apparently, site conditions

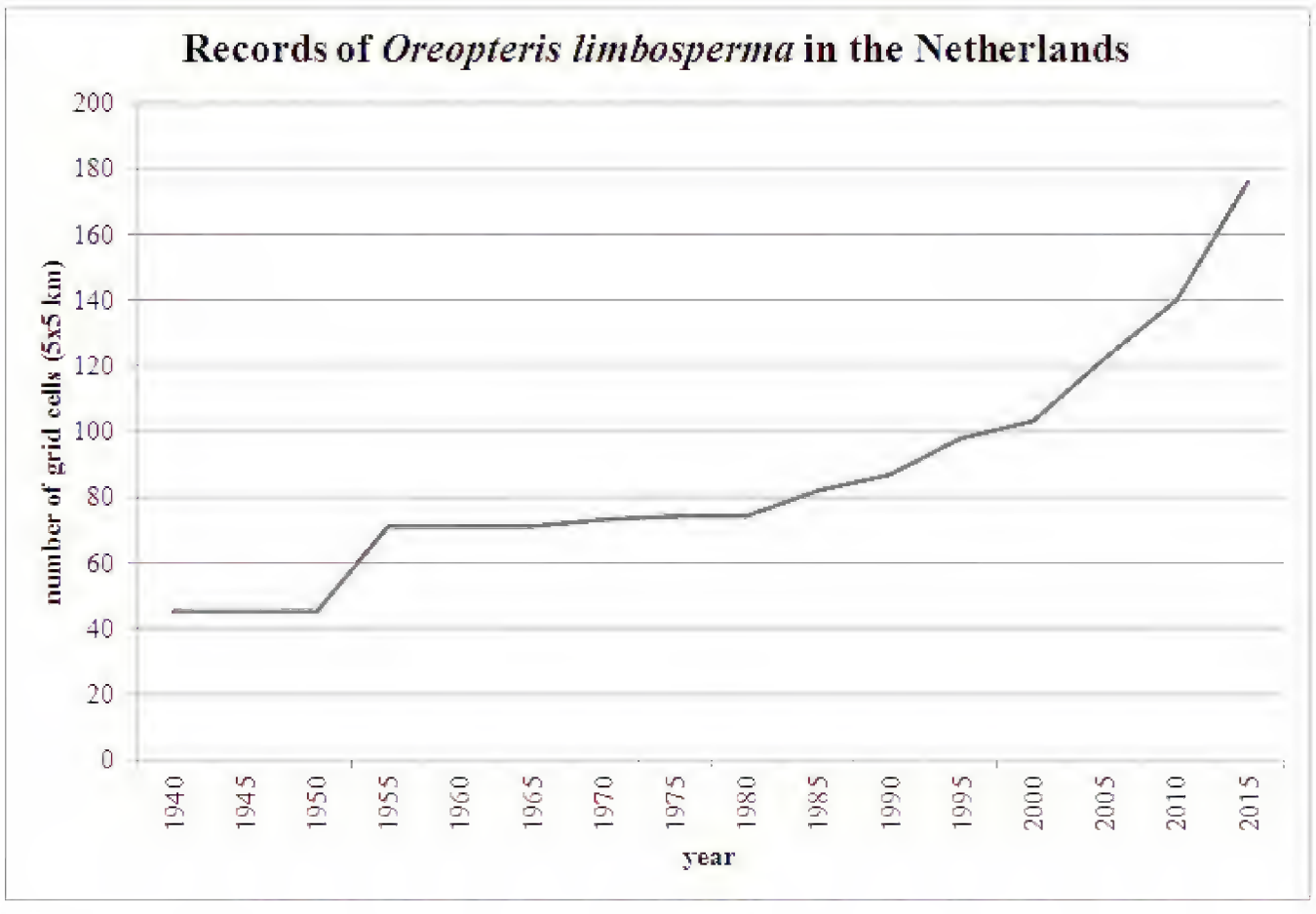

Figure 5. Cumulative numbers of grid cells (5x5 km) with *Oreopteris limbosperma* in the Netherlands between 1940 and 2015. (Data source: verspreidingsatlas.nl)

are developing into a favourable state for the establishment of *Oreopteris* in these landscapes after about 100 years, especially in ditch sides in these plantations. In most sites where the species occurs it is only present in very small populations, sometimes only consisting of one single plant. This is in sharp contrast with the situation in West Scotland, where the species usually forms dense stands, and where a mature fern community is developed.

The difference between the mature Scottish fern-meadows and the juvenile Dutch *Oreopteris* community is expressed in particular in the average number of fern species: 6.2 in the Scottish relevés, and only 3.9 in the Dutch ones. Remarkably, in the only relevé that was published by Bremer (2016) which can compete with the Scottish one in this respect (relevé 2003.20 in the table published by Bremer), *Dryopteris borreri* was recorded, the only observation of a species of the *Dryopteris affinis* complex in the association in the Netherlands.

Considering all available data, including vegetation structure, fern species numbers, as well as the ominipresence of the described fern-meadow vegetation, the *Luzulo-Thelypteridetum* may be optimally developed in the lowlands and low mountain areas of West Scotland. In the Central European lower mountain regions, *O. limbosperma* can form dense stands locally, but the number of fern species drops notably in comparison with the fern species numbers in the Scottish fern-meadows. In the Netherlands, the distribution area of *Oreopteris* is still developing, and it is only rarely found in a dense fern vegetation rich in pteridophytes.

The major absent in the Dutch relevés published by Bremer (2016) and Weeda & Haveman (2017) is *Dryopteris cambrensis*, which is so prominently present in the Scottish relevés. This species was discovered only recently in the Netherlands, *viz.* in 2010 by Koos Ballintijn in the Purmerbos just north of Amsterdam. The species is recorded in eight grid cells now, although their identity is not yet verified in all cases (oral comm. Sipke Gongrijp). Whether the species is really as rare as the online map (verspreidingsatlas.nl) suggests is not clear. The apomicts in the *Dryopteris affinis* aggregate are difficult to separate, although it is possible after some experience. Considering the distribution pattern in the UK, where the species seems to be much more restricted in the east than in the west, *D. cambrensis* may be and remain a rare species in the Netherlands. It remains an open question whether this species will be able to establish in the *Luzulo-Thelypteridetum*. Its dispersion might be adequate to reach the sites eventually, but whether the conditions for the establishment of the species are appropriate is not certain. The current occurrence of the species in dense (young) forest plantations suggest that *D. cambrensis* is confined to rather high levels of air humidity. In this respect, the environmental conditions in which the *Luzulo-Thelypteridetum* develops might be favourable also for the growth of *D. cambrensis* too. The future will show whether this and other fern species can become established in this association in the Netherlands. I expect however, that the *Luzulo-Thelypteridetum* never will become as species rich and luxuriant as in the coastal areas of Argyll.

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MARSILEA AEGYPTIACA (MARSILEACEAE) ON THE MEDITERRANEAN ISLAND OF ELAFONISOS (LACONIA, PELOPONNESE, GREECE)

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ABSTRACT

The water-clover species *Marsilea aegyptiaca* was first detected on the Mediterranean island of Elafonisos (Peloponnese, Greece) nearly 25 years ago. This was the first record for the species as part of the European flora. Recent work has shown that *M. aegyptiaca* still occurs at the site, and data are presented concerning its identification, habitat and distribution. Morphological characters of all known European species within the genus are compared.

INTRODUCTION

Water-clovers (*Marsilea* L.) are heterosporous ferns and the most species rich group within the Marsileaceae. The family additionally comprises the pillworts (*Pilularia* L.) and the monotypic genus *Regnellidium* Lindm. All three genera are aquatic to semi-aquatic rhizomatous plants with roots and leaves born at nodes and sori arranged in sporocarps (Kramer, 1990; Nagalingum *et al.*, 2006). Recent phylogenetic studies have revealed that the Clover ferns (Marsileaceae) together with the Floating ferns (Salviniaceae; *Salvinia* Seg. and *Azolla* Lam.) represent a monophyletic group of heterosporous ferns within the fern clade, which evolved in the Mesozoic (Pryer, 1999; Smith *et al.*, 2006; Nagalingum *et al.*, 2006). Twentieth century treatments of the genus mainly focussing on morphology have been published for Africa (Launert, 1968, 1970, 1971, 1984), Australia (Jones, 1998), India (Gupta, 1962), and the Americas (Johnson, 1986). Recent molecular studies have thrown some light on the phylogenetic relationships within *Marsilea* (Nagalingum *et al.*, 2007, 2008; Whitten *et al.*, 2012).

During extensive field work on the island of Elafonisos in 1991 (Laconia, Peloponnese, Greece; see Jagel, 1992) the semi-aquatic Water-clover species *Marsilea aegyptiaca* Willd. was found growing abundantly in a seasonal pool. This was not only the first record for Greece but also the first true European occurrence of the species known at that time; its only known station at the time being from the Lower Volga in Russia (Jalas & Suominen, 1972; Tutin *et al.*, 1993; Tzvelev, 2012) and an erroneous record for Spain (Alcober *et al.*, 1980). The site was reinvestigated in 2016 and *M. aegyptiaca* confirmed to be still thriving at its obviously undisturbed habitat.

In regard to the biogeographical importance of the record, more detailed and comprehensive data are given below.

BIOLOGY AND IDENTIFICATION

Water-clover species (*Marsilea* L.) are in general a variable and frequently confusing group of plants and depending on the life phase, are nearly impossible to separate from each other. Most members of the genus inhabit seasonally dry areas inundated only

during the rainy season and like most aquatic plants are characterized by a phenotypic plasticity, which renders identification on a species level quite difficult. This is emphazised when plants are in their sterile, vegetative growth stage with submerged rhizomes and floating leaves on the water surface. Sporocarps are formed only in the terrestrial life stage, but are essential for species determination. Sterile, aquatic plants lacking sporocarps are nearly impossible to identify, because the different species in that life stage are morphologically very similar.

Marsilea aegyptiaca (Figure 1) belongs to a group of xerophytic members within the genus and is adapted to extreme dry conditions. Crouch *et al.* (2011) report that the species in Southern Africa inhabits arid semideserts and is obviously able to exist for several years without being submerged. Consequently *M. aegyptiaca* is quite small in its overall appearance (stipes in the dry land form max. 5 cm long with pinnae max. 1 cm long) and shows hairy leaves (Figure 2 a-d), a feature often displayed by xerophytic *Marsilea* species. Nevertheless this is a very unstable and variable character, because hairs on the leaves and petioles readily occur in hydrophytic species too, when being in their terrestrial life stage. The pinnae of the land form are narrowly cuneate and pilose with the distal margin being slightly truncate and shallowly bilobed. The sporocarp of *M. aegyptiaca* is quite distinct (Figure 3): usually appearing in clusters of two or more on short, free pedicels (2-8 mm), almost squarish in lateral view, with a distinct lateral furrow, densely pilose at first, becoming subglabrous later, lacking an inferior but mostly having a prominent superior tooth. In its aquatic life stage *M. aegyptiaca* is less distinct (see above). The floating leaves have stipes up to 30 cm long, broadly obovate, glabrous and larger pinnae (max. 2.5 cm) with rounded and shallowly sinuate distal margins (Figure 4 a, b).

Figure 1. *Marsilea aegyptiaca* at its growing site on the island of Elafonisos.

Table 1 shows the morphological characters of all known European species within the genus *Marsilea*. The former listed Azorean endemic species *M. azorica* Launert & Paiva has recently been shown to be a misidentification and synonymous with the invasive *M. hirsuta* R. Br. from Australia and Asia (Schaefer *et al.*, 2011) and therefore is excluded here.

GEOGRAPHY, HABITAT, AND ECOLOGY

Elafonisos is located in the region of Laconia, an administration unit of the Peloponnese. The island lies just off the Southwest coast of Malea Peninsula and is separated from it by a 600 m wide strait. The history of Elafonisos as an island is short, being part of the peninsula in former times. Therefore, it is not surprising that the largest part of the flora is typical for the South Peloponnese. However, some species show relations to the floristic region of the South Aegean (Jagel, 1992).

In the Northwest part of Elafonisos at Leptos Kavos a seasonally moist habitat of about 1000 m² exists (Figure 5 a, b), at a distance of not more than 100 m from the Mediterranean sea. From late autumn until very early spring the shallow depression is

Figure 2 a, b, c, d. *Marsilea aegyptiaca*, fertile dry land plant in terrestrial life stage with hairy leaves.

Table 1: Macromorphological characters of the European species of *Marsilea* based on Gupta (1962), Launert (1968, 1983, 1984), Castroviejo *et al.* (1986), Johnson (1986), Prelli (2001), Tutin *et al.* (1993), Delgado Vázquez & Plaza Arregui (2010), Crouch *et al.* (2011), Schaefer *et al.* (2011).

		M. quadrifolia	***M. strigosa***	***M. batardae***	***M. aegyptiaca***
Sporocarp	**Arrangement**	clustered, 2-3, rarely solitary stalked	mostly solitary crowded in two regular imbricating rows along the rhizome sessile	solitary or in loose groups of 2-3, not crowded along the rhizome stalked	clustered, usually 2, rarely solitary stalked
	Shape	oblong-ellipsoid, beanshaped longer than high not laterally flattened	oblique-elliptic, obliquely squarish or rectangular, obovoid longer than high laterally usually flattened	irregularly squarish to subcircular as long as high laterally usually flattened	squarish as long as high laterally flattened
	Size	3-6 mm	3-5 mm	3-4.5 mm	2-3 mm
	Teeth	superior tooth 0-1 (short to indistinguishable) inferior tooth 0	superior tooth 1 (short to indistinguishable) inferior tooth 0-1	superior tooth 1 (prominent) inferior tooth 0-1	superior tooth 1 (prominent, blunt to acute) inferior tooth 0
	Surface	glabrous (hairy only when young) without a furrow on the lateral sides	strigose or silky pubescent, later subglabrous without a furrow on the lateral sides	strigose or silky pubescent, later subglabrous without a furrow on the lateral sides	densely pilose later subglabrous with a distinct curved vertical furrow on the lateral sides
	Pedicel (stalk of sporocarp)	2-20 mm 2- to 4-branched, rarely unbranched	1-2 mm unbranched	2-8 mm unbranched	2-8 mm unbranched
Rhizome		long, creeping, profusely branched internodes more than 10 mm	short, caespitose, sometimes branched nodes crowded	long, creeping, profusely branched internodes 5-20 mm	long, creeping to subcaespitose internodes 5-10 mm (sometimes longer)
Pinnae	**Shape**	obovate-cuneate apex entire to undulate, rounded	obdeltate-cuneate apex entire to crenulate, rounded	obdeltate-cuneate apex entire to crenate	narrowly cuneate to obdeltate apex deeply crenate to sinuate or entire, rounded
	Pubescence	glabrous	glabrous to sparsely hairy	glabrescent	hairy or glabrous

filled with fresh water not influenced by salt water.

Marsilea aegyptiaca is very frequent in this small area, with hundreds or thousands of fronds being found. A smaller population exists more or less 50 m east of the pond at the border of a scrub. The sub-surface of the site is formed by limestone rocks (Symeonidis, 1969), covered by a shallow layer of sandy fine soil. After the beginning of the rainy season in autumn e.g. when *Narcissus serotinus* L. is flowering and when the shallow depression is filled up with rainwater, *Ranunculus peltatus* Schrank subsp. *fucoides* (Freyn) Munoz Garmendia (= *Ranunculus saniculifolius* Viv.) can be found as a water plant in the pond. At this time of year the *Marsilea* grows in its aquatic life stage (Figure 4). The pond is framed by tufts of *Juncus heldreichianus* Parl. and *Schoenus nigricans* L. At the end of winter or in early spring, usually at the end of March, the pond rapidly dries out within a few weeks. Species found growing together with *M. aegyptiaca* are *Anagallis foemina* Miller, *Briza minor* L., *Isoetes phrygia* (Boiss.) Hausskn., *Isolepis cernua* (Vahl) Roem. & Schult., *Juncus capitatus* Weigel, *Juncus hybridus* Brot., *Lythrum borysthenicum* (Schrank) Litv., *Lythrum hyssopifolia* L., *Mentha pulegium* L., *Plantago weldenii* Rchb., *Polypogon maritimus* Willd., *Ranunculus muricatus* L., *Romulea ramiflora* Ten. *Sagina maritima* G.Don, *Solenopsis laurentia* (L.) C.Presl, *Trifolium lappaceum* L. *Trifolium resupinatum* L., and *Triglochin barrelieri* Loisel. Most of these are highly specialized and characteristic for such sites in the Peloponnese.

DISTRIBUTION

Marsilea aegyptiaca is mainly an African species, recorded for Ethiopia, Botswana,

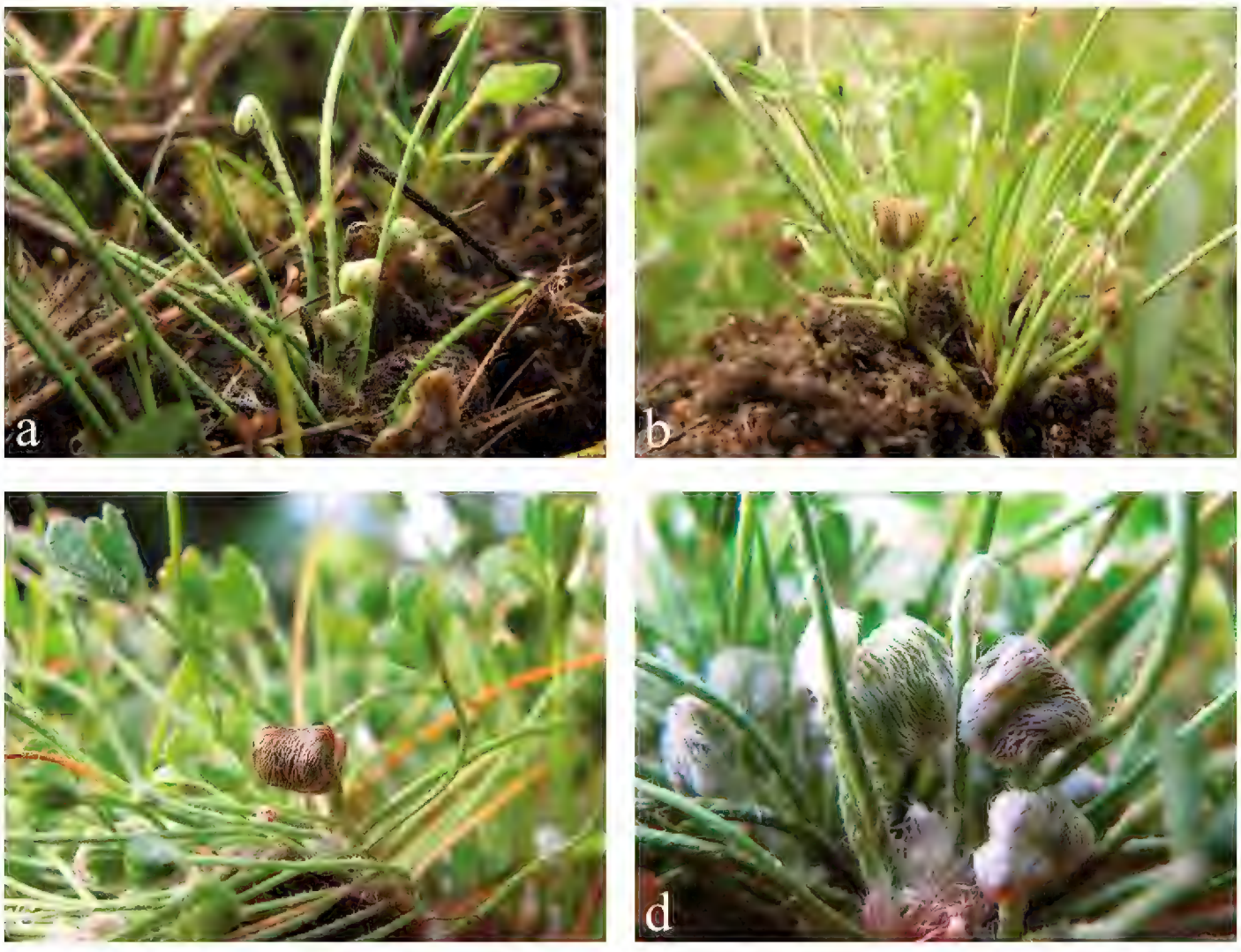

Figure 3 a, b, c, d. *Marsilea aegyptiaca* showing characteristic clustered, squarish, pilose sporocarps with lateral furrow and blunt superior tooth on short pedicels.

Namibia, South Africa, Sudan, Egypt, Tunisia, Algeria, Libya, and Madagascar (Launert, 1984; Crouch *et al.*, 2011). The species also extends its range to the east with occurrences on the Indian subcontinent (Gupta, 1962; Sharma, 2005).

Until the 1990s *M. aegyptiaca* was known from Europe only from the river Volga and its delta near the Caspian Sea in Russia (Jalas & Suominen, 1972; Tutin *et al.*, 1993; Tzvelev, 2012). A record for Spain (Alcober *et al.*, 1980) turned out to be a misidentification and the plants are now known to belong to a different species, *Marsilea batardae* Launert, occurring in Southwest Spain and Southern Portugal (Launert, 1983; Castroviejo *et al.*, 1986; Rosselló-Graell *et al.*, 2000; Prelli, 2001; Delgado Vázquez & Plaza Arregui, 2010).

The discovery of *M. aegyptiaca* on the Peloponnesian island of Elafonisos in 1991 therefore was a remarkable addition to the knowledge concerning the range of the species now extending into the Eastern Mediterranean (Jagel, 1992) and representing the first record for Greece and the European Union. Later a second occurrence for the region has been reported from Cyprus (Hand, 2011), validating the species as an element of the European mediterranean flora.

HABITAT AND THREATS

In former times sites of *M. aegyptiaca* on Elafonisos were used for agricultural purposes

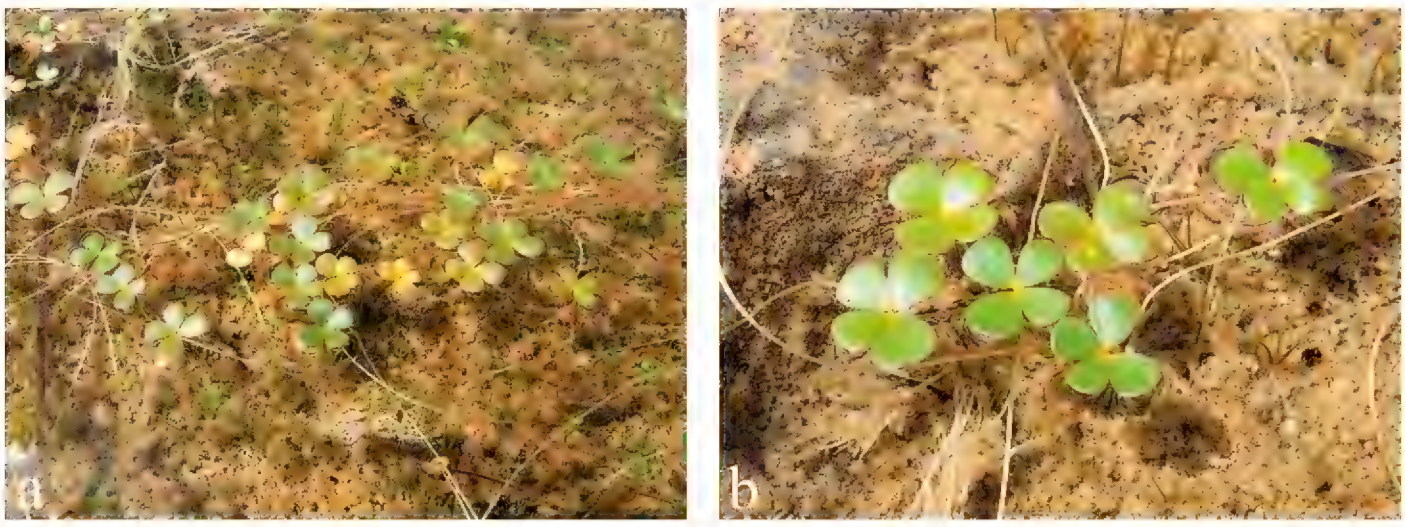

Figure 4 a, b. *Marsilea aegyptiaca*, sterile plant with floating leaves in aquatic life stage.

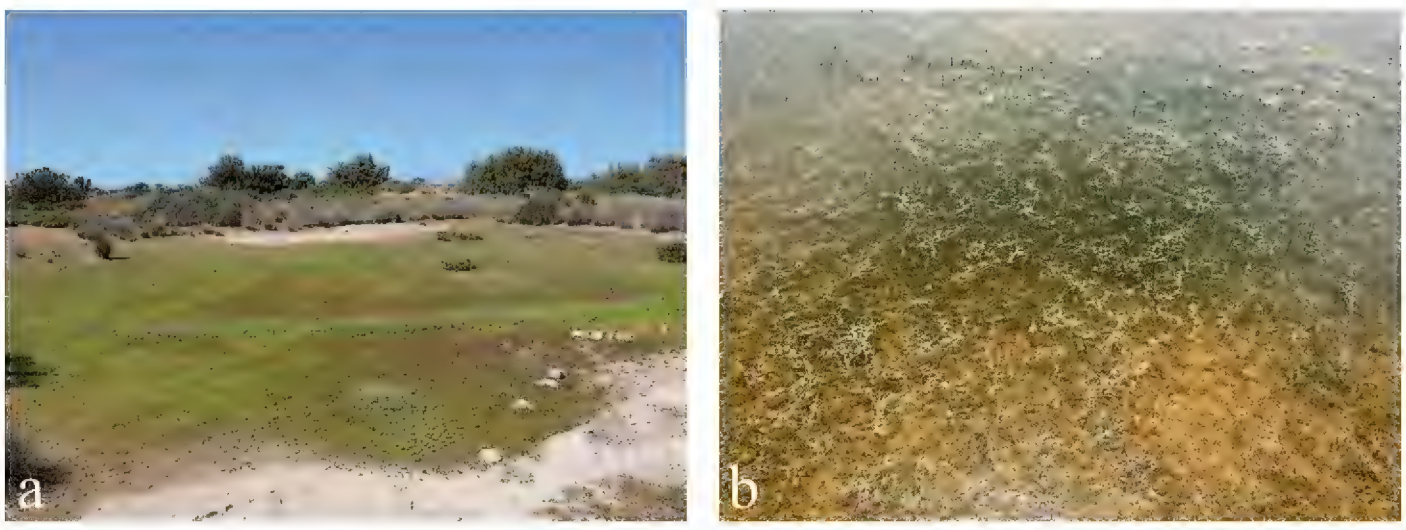

Figure 5 a, b. Habitat of *Marsilea aegyptiaca* on Elafonisos, dried up in spring (a) and flooded in winter (b).

perhaps because of the good water supply, with evidence of several low walls of collected field stones. Nowadays there is no noticeable human influence, neither huts, houses nor stables are in the proximity so no current threat for the fern is perceived. The fact that the species has been known there for nearly 25 years now with no obvious change to the site supports this assessment.

A large area of similar seasonally wet ponds is situated nearby on the mainland in Viglafia north of the beach of Punta. The area seems to be comparable with the pond of Elafonisos but is quite overgrazed and in parts more brackish. Although it has been investigated intensively over several years no plants of the Water-clover could be found although most accompanying plants of the Elafonisos site were present. However the site is nevertheless remarkable for hosting some very rare plant species which could not be found on Elafonisos: *Callitriche brutia* Petagna, *Cicendia filiformis* (L.) Del., *Crassula vaillantii* (Willd.) Roth, *Isoetes gymnocarpa* (Gennari) A.Braun, *Isoetes histrix* Bory, and *Myosurus heldreichii* Heldr. ex H.Lév. Additionally a third Quillwort species, *Isoetes phrygia* (Boiss.) Hausskn., is present here (as it is at the *Marsilea* site on Elafonisos), together with a hybrid probably involving this taxon.

ACKNOWLEDGEMENTS

The authors would like to thank Dr. H. W. Bennert (Ennepetal [formerly of Ruhr-University of Bochum], Germany) for the initial confirmation of *Marsilea aegyptiaca* in 1992. He also contributed with literature and helpful discussions. Dr. V. M. Dörken (University of Konstanz, Germany) also supplied us with literature. Dr. A. Troia (University of Palermo, Italy) is gratefully acknowledged for his help with the determination of the different *Isoetes* species at the sites.

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SHORT NOTE

HYPODEMATIUM CRENATUM SUBSP. *CRENATUM* (HYPODEMATIACEAE): A NEW DISTRIBUTIONAL RECORD FOR GUJARAT STATE

The state of Gujarat is divided into five zones *viz*., Kutch, Saurastra, North, Central and South Gujarat. These zones are based on climate and geographic location. The district Junagadh is located on the Kathiawar peninsula in western Gujarat (Saurastra zone). It contains the Gir National Park and Girnar wildlife sanctuary, which is the only home for Asiatic lions. Girnar hills are also declared as a forest reserve for bamboos (Nakar & Jadeja, 2015), and '*Girnari Giddh*', the long-billed vulture, is found only in the Girnar hills. The Girnar region alone accounts for about 25 per cent of the species in Gujarat state (Patel *et al.*, 1961). However, lycophyte and fern diversity of the whole of the Gujarat state including Saurashtra regions (particularly Junagadh) is less understood, although recently there have been a few reports on the pteridophyte diversity of Central, North and South Gujarat (Kachhiyapatel *et al.*, 2015, 2016; Rajput *et al.*, 2016). The present investigation was carried out to study pteridophytes from Girnar hills. During this survey an interesting pteridophyte was collected which, after critical observation of morphological characters, was identified as *Hypodematium crenatum* (Forssk.) Kuhn. subsp. *crenatum* and it is reported here as new distributional record for Gujarat state. The identification was confirmed by comparing generated nucleotide sequences with the GenBank database, and the sequence data were submitted to BOLD.

The genus *Hypodematium* in the family Hypodematiaceae is represented by 20 species in the world (PPG-I, 2016). A sole species of *Hypodematium* (divided into three subspecies *viz*., *H. crenatum* subsp. *crenatum*, *H. crenatum* subsp. *loyalii* Fraser-Jenk. & Khullar and *H. crenatum* subsp. *mehrae* Fraser-Jenk.) has been reported from India (Fraser-Jenkins, 2008). We have found a single subspecies, *H. crenatum* subsp. *crenatum,* for Gujarat state. Its description, range of distribution, ecology, conservation status and specimen examined is given.

Systematic Treatment

Hypodematium crenatum (Forssk.) Kuhn, subsp. *crenatum*, Fraser-Jenkins, Taxon. Revis. Indian Sub-continental Pteridophytes., 204 - 206, 612. 2008; Patil, Systematic Studies on Pteridophytes of Satara District, 111-112. 2014.

Hypodematium crenatum (Forssk) Kuhn. Manickam and Irudayaraj, Pterid. FI. W.

Hypodematium hirsutum (Don) Ching. Indian Fern J. 1(1-2): 49.1985.

Plant lithophytic, perennial herb; *rhizome* long creeping, densely red-brown scaly, giving woolly look to rhizome; *scales* 1-2 cm × 1-3 mm, red-brown, oblong lanceolate-lanceolate, glossy, apex long acuminate, margin entire; *frond* 20-30 cm × 15-20 cm, green-dark green, bipinnatified-tripinnatifid; *stipe* 10-18 cm long, brown, densely scaly at base, grooved, glabrous above; *lamina* 5-12×15-20 cm, bi-pinnatifid-tri-pinnatifid, ovate, apex acute, base cuneate, basal half tri-pinnatifid, distal half base bi-pinnatifid, distal most part simply pinnatifid; *pinnae* 6-10 pairs, subopposite, lanceolate, apex acute, base decurrent, pale brown, stiff, hairs sparsely-densely distributed; texture herbaceous; *vein* forked 3-4 times, indistinct above and below, free, reaching up to margin; *sori* median on the vein lets in two rows; indusia reniform, entire, densely covered with short stiff hair; *spores* 45-55 µm in dia., reniform to ellipsoid, exine with prominent

protuberances (and see Figure 1).
Distribution: World: Africa, China, India, Japan, Malaysia, Myanmar, Philippines and Thailand
India: Himachal Pradesh, North East India, Punjab, Gujarat, Maharashtra, Kerala.
Gujarat: Junagadh

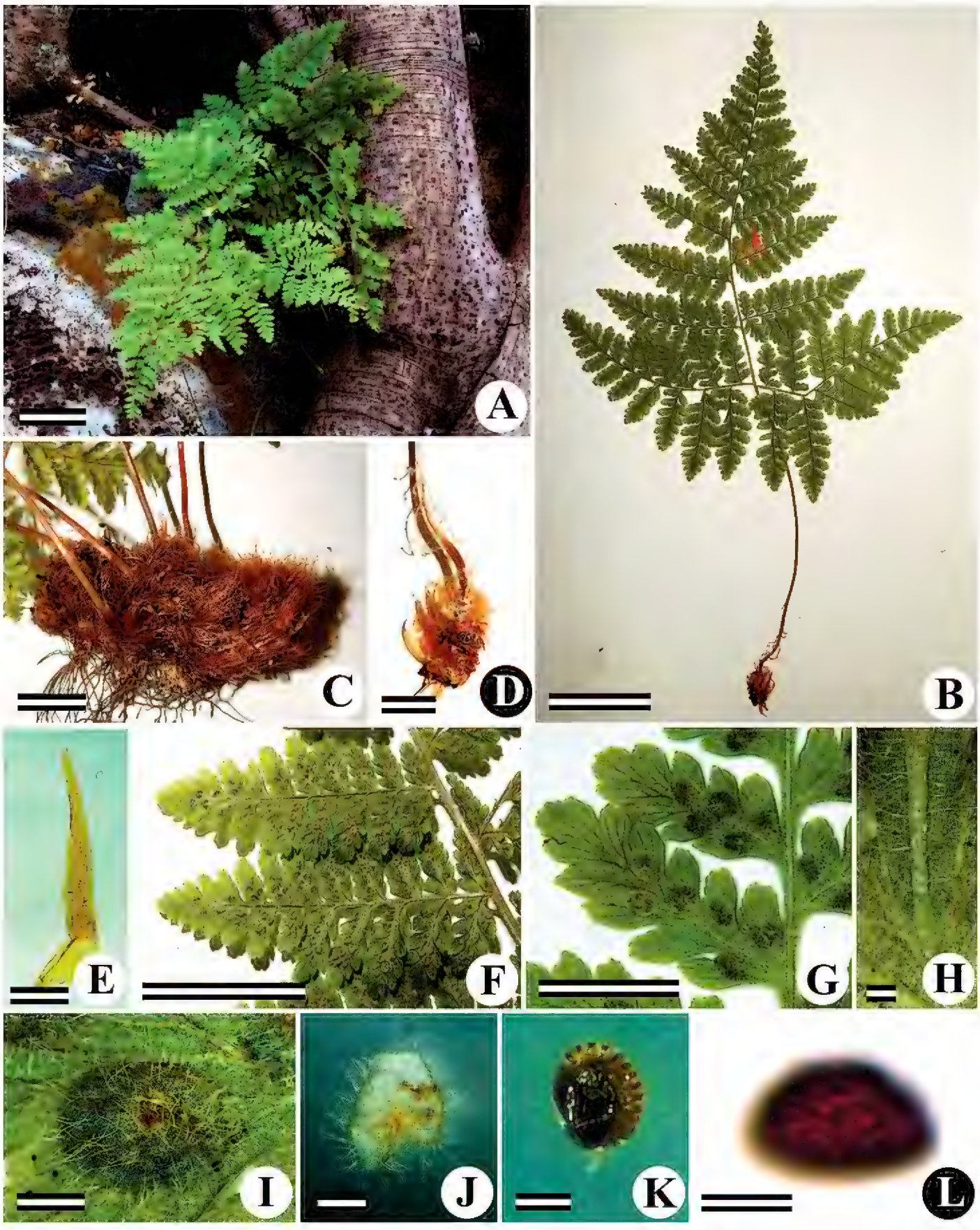

Figure 1. A: Habit of *Hypodematium crenatum* subsp. *crenatum*. **B:** Frond **C:** Rhizome **D:** Stipe base showing dense scales **E:** Stipe base scale **F:** Pinna **G:** Pinnules showing arrangement of sori **H:** Enlarged view showing hairs on costules **I:** Sorus **J:** Indusium **K:** Sporangium **L:** Spore. **Scale bar:** A-3 cm, B-3 cm, C- 1cm, D-0.5 cm, E-2 mm, F-2 cm, G-5 mm, H-1mm, I-0.5 mm, J-0.5 mm, K-100 μM, L-25 μM.

BOLD ID: MIPDG013-15
Phenology: **Vegetative phase**: June-September; **Reproductive phase:** October-December
Ecology: Lithophytic, collected from rock crevices at Girnar hill slopes (on the way to Sitavan), between 650-700 m.
Specimens Examined: INDIA-Maharashtra: Kolhapur Dt., Pankala, alt 1000 m., 26/10/1962, Bhandare, **BLAT**; 02/01/1952, V. D. Vartak (BLAT205), **BLAT**; Satara Dt., Wai Tehasil; Panchagani, alt. 1100 m., Oct. 1918, Blatter (BLAT1211), **BLAT**; Satara Dt., Panchgani, alt. 1200 m., Sept. 2014, (SMP10071) **SUK**; Gujarat: Junagadh dt, Girnar hills, on the way to Sitavan, 680 m, (21°32'03.50" N, 70°31'28.10" E, at 668 m), *R.N. Kachhiyapatel & K.S. Rajput* 129, 26/12/2014, **BARO**.

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SHORT NOTE

ELEVEN NEW COMBINATIONS FOR MALESIAN FERNS

The preparation of a checklist of pteridophytes from Gunung Mulu National Park, Sarawak, necessitates eleven new combinations to bring the generic treatment into line with PPG 1 [Pteridophyte Phylogeny Group] (2016).

NEW COMBINATIONS

DAVALLIACEAE

1. Davallia grammatosora *(Copel.) Parris* **comb. nov.,** based on *Davallodes grammatosora* Copel., Philipp. J. Sci. Bot. 3: 34, t. 6 (1908), ***syn.*** *Davallodes hirsuta* (C.Presl) Copel. *non Davallia hirsuta* Sw. (1801). Type: Philippines, Mindanao, Copeland 1724 (**BM**, **P**).

2. Davallia pusilloides *(Copel.) Parris* **comb. nov.,** based on *Humata pusilloides* Copel., Sarawak Mus. J. 2: 338 (1917). Type: Philippines, Mindanao, Zamboanga, San Ramon, May 1910, *E B Copeland* 153 (**BM**, **K**, **MU**, **P**, **PNH, SING, UC**).

3. Davallia subvestita *(C.Chr.) Parris* **comb. nov.,** based on *Humata kinabaluensis* var. *subvestita* C.Chr., Gardens' Bulletin Straits Settlement 7: 232 (1934). Type: Borneo, Sabah, Mt Kinabalu, near Lobang, 18 Nov. 1931, *R E Holttum SFN* 25549 (**BM**, **BO**, **K**, **SING**).

HYMENOPHYLLACEAE

1. Abrodictyum saxatile *(T.Moore) Parris* **comb. nov.,** based on *Trichomanes saxatile* T.Moore, Gard. Chron. 1862: 45 (1862). Type: Borneo, collector not specified (**K**?).

2. Abrodictyum setigerum *(Backh. ex T.Moore) Parris* **comb. nov.,** based on *Trichomanes setigerum* Backh. ex T.Moore, Gard. Chron. 1862: 45 (1862). Type, Borneo, collector not specified (**K**?).

3. Crepidomanes novoguineense *(Blume) Parris* **comb. nov.,** based on *Trichomanes novoguineense* Brause, Bot. Jahrb. Syst. 49: 7 (1912). Type: Papua New Guinea, Lager "Hochmoos" 65 km südwärts der Tami-Mündung, 1600 m, Juli 1910, *L Schulze* 33/35 (**B**).

4. Crepidomanes teysmannii *(Bosch) Parris* **comb. nov.,** based on *Trichomanes teysmannii* Bosch, Ned. Kruid. Arch. 5: 142 (1861). Type: Sumatra, *Teysmann* s. n. (**L**).

5. Hymenophyllum album *(Blume) Parris* **comb. nov.,** based on *Trichomanes album* Blume, Enum. Pl. Javae: 226 (1828). Type: Java, *Blume* s. n. (**L**).

POLYPODIACEAE

1. Leptochilus bolsteri *(Copel.) Parris* **comb. nov.**, based on *Polypodium bolsteri* Copel., Philipp. J. Sci. 1, Suppl. 4: 257, pl. 4a (1906). Type: Philippines, Mindanao, Surigao, April 1906, *Bolster* s. n. (**MICH**).

THELYPTERIDACEAE

1. Amblovenatum immersum *(Blume) Parris* **comb. nov.,** based on *Aspidium immersum* Blume, Enum. Pl. Javae: 156 (1828). Type: Java, *Blume* s. n. (**L**).

2. Amblovenatum paraphysophorum *(Alderw.) Parris* **comb. nov.,** based on *Dryopteris paraphysophora* Alderw., Bull. Bot. Buitenzorg, ser. 3, 2: 143 (1920). Type: Sumatra, Lebong Tandai, *C J Brooks* 250S (**BM, BO**).

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